Studies on the Processing of Red Cherries. I. Changes in Fresh Red Cherries Caused by Bruising, Cooling, and Soaking

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Data are given that show how the weight, firmness, and soluble-solids content of fresh red cherries are affected by bruising, temperature, soaking, and period of storage. Not all changes that occur in cherries when soaked are caused by soaking alone. Bruising lessens the gain in weight of cherries when soaked and increases the loss of soluble solids and acids.

Soaking fresh red cherries in cool water before processing provides a convenient means of cleaning, cooling, and storing them. Some changes that occur in the cherries when they are soaked have been described previously *(2, 3, 4, 5, 6)*. No general statement concerning the changes can be made, however, since the studies were somewhat limited in scope and conflicting results were obtained. Peterson *(4)* found that cherries lose weight during the first 5 or 6 hours of soaking, but thereafter steadily gain weight. The cherries used by Swingle *(6)* decreased in weight as much as 4.4% when soaked for 4 hours. Langer and Fisher *(2)*, however, observed no significant changes in the weight of cherries when soaked. Reynolds and Reynolds *(5)* expressed the opinion, commonly accepted in the industry, that cherries retain all their natural juices during soaking. On the other hand, Peterson *(4)* and Marshall *et al. (3)* reported that cherries lose appreciable quantities of soluble solids if soaked for more than about 12 hours.

Part 1 of the present study shows how conflicting results on the effects of soaking might easily be obtained. Cherries from the same lot, for instance, were made to gain, lose, or show no change in weight merely by varying the degree of bruising. The cherries were affected also by factors such as the temperature and duration of soaking and the period of natural aging or "conditioning." The present paper deals only with changes in fresh cherries; changes in canned cherries induced by various preprocessing treatments are described in the second part of this study *(1)*.

MATERIALS AND METHODS

In most experiments, commercial cherries were not used because they were not sufficiently uniform in size, maturity, extent of bruising and post-harvest history. Instead, the cherries (Montmorency) were obtained from 2 similar trees in the orchard at Michigan State Colloge, East Lansing, Michigan, in 1949. The trees had been sprayed with Tennessee 26, a copper fungicide. The cherries were picked with a minimum of bruising, and all samples were essentially uniform in respect to maturity and size of cherries. Only samples of average maturity, as indicated by their red color, were used.

Experiments were begun within 2 hours after the cherries were picked, and were conducted in rooms of constant temperature. Firmness was measured with a pressure tester *(8)*, and the soluble-solids content was estimated with an Abbé refractometer, except where otherwise noted. Some samples were bruised by dropping the cherries from a predetermined height onto a stainless steel tray.

RESULTS

Effects of soaking. Unbruised cherries soaked in distilled water for 77 hours increased 10% in weight (Table 1). The increase was more rapid at 21° C. (70° F.) than at 10 or 1° C. (50 or 34° F.). At the last 2 temperatures, the increase was roughly proportional to the soaking period, the increase being 4% after 24 hours. With a gain in weight of 10%, a large proportion of the cherries cracked.

The firmness of the cherries increased with prolonged soaking at each of the 3 temperatures. The increase was greatest and most rapid in cherries soaked at 1° C. (34° F.). The increase, however, cannot be attributed entirely to soaking, as will be shown. Cherries soaked in a dilute solution of calcium chloride were slightly firmer than those soaked in water. Meanwhile, the soluble solids content of all samples decreased, the largest decrease occurring in the samples soaked at 21° C. (70° F.). Table 3 and the results of Peterson *(4)* show also that cherries decrease in acidity when soaked.

In some respects the behavior of bruised cherries (dropped twice from a height of 3 feet) contrasted sharply with that of unbruised fruit. At 21° C. (70° F.) bruised cherries lost weight when soaked, and at 1° C. (34° F.) they had gained only 1% in weight after 77 hours. Although they increased in firmness during soaking, their firmness at all stages was lower than that of unbruised cherries. Furthermore, although the changes in their soluble-solids content paralleled those of unbruised cherries, the total quantity of soluble solids leached from them was about double that from unbruised fruit.

The effects of bruising on soaked cherries were roughly proportional to the extent of bruising (Table 2). Slightly bruised cherries (dropped from a height of 1 or 2 feet) responded to soaking in a manner not much different from that of unbruised cherries. The differences became pronounced, however, when the cherries were moderately to severely bruised (cherries dropped 2 to 4 times from a height of 3 feet).

Limited data (bottom of Table 2) indicated that many samples of commercial cherries were moderately to severely bruised, since they had a comparatively low degree of firmness and did not gain appreciably in weight when soaked. A satisfactory evaluation of commercial cherries, however, must await further study; the effects of bruising may be altered or obscured by differences in their post-harvest history.

The principal pathway for the exchange of substances between the cherries and the soaking medium was the area of tissue exposed by the removal of stems (Table 3). Cherries with stems attached gained 2.4% in weight and lost only 0.3% of their soluble solids and 0.6% of their total acids when soaked for 24 hours. The corresponding values for cherries without stems were 7.1, 3.1, and 1.2%. The exchange of materials between the bruised cherries and the soaking medium also probably took place largely through the tissues exposed by the removal of stems, since there were no lesions in the skins. The effect on the exchange of permitting cherries to stand in air for several hours at room temperature after removal of their stems was not determined.

Effects of storage in air. To help define the changes in cherries caused by soaking alone, control samples were stored in air for similar periods and at the same temperatures as the soaked cherries. Since fresh cherries are alive and capable of changing within themselves, not all the changes that occur during soaking can be ascribed to soaking.

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TABLE 1

Changes in unbruised and bruised red cherries during soaking in distilled water or in 0.1% calcium chloride solution

Temperature and treatment[b] of cherries	Change in weight, %			Firmness, % compression				Soluble-solids content, %				Loss of soluble solids, % of total[c]
	Hours soaked			Hours soaked				Hours soaked				Hours soaked
	10	24	77	0	10	24	77	0	10	24	77	77
21° C.												
Unbruised	+3	+6	+10	24	23	23	18	13.0	12.7	11.8	10.0	7
Bruised	−1	−1	− 1	33	32	30	25	13.0	12.8	12.4	10.2	14
10° C.												
Unbruised	+2	+4	+10	....	....	22	17	13.0	12.6	12.0	10.5	7
Unbruised, 0.1% $CaCl_2$	+2	+4	+10	....	....	21	15	13.0	12.6	12.6	11.0	7
1° C.												
Unbruised	+2	+4	+10	....	21	20	16	13.0	12.8	12.7	10.9	5
Bruised	0	0	+ 1	....	27	26	23	13.0	12.8	12.7	11.1	12

[b] The bruised cherries were dropped twice from a height of 3 feet.

[c] Soluble solids leached from the cherries into the soaking media were determined gravimetrically.

Lowering the temperature of the cherries caused a rapid increase in firmness (Table 4). The difference in firmness among samples stored at 21, 10, and 1° C. (70 50, and 34° F.) was maintained or became greater throughout the experiment. There was, however, a second factor, not completely dependent on temperature, which affected firmness. This factor included the vital changes in the cherries themselves. It was expressed by the gradual increase in firmness of cherries stored at a constant temperature of 1° C. It also was shown by the initial increase in firmness of cherries picked and stored at 21° C. The cherries were least firm immediately after being picked, owing partly to the inevitable bruising attendant on the removal of their stems. After a short period of aging or "conditioning," however, the bruised areas evidently were repaired or strengthened, and the cherries temporarily became firmer. Similar increases in firmness of freshly picked cherries were observed in numerous other samples.

During storage, the cherries of course lost weight, but at the same time the percentage of soluble solids increased. The greatest changes occurred in the samples stored at 21° C. At 1° C. the cherries were relatively stable. Some unbruised samples were stored in air at this temperature for as long as 12 days without spoilage.

Bruised cherries lost more weight and were less firm than were unbruised cherries. After about 51 hours' storage, however, bruised cherries at 1° C. were firmer than were unbruised cherries at 21° C.

DISCUSSION

From the collective data in the tables, a number of observations may be made concerning the changes in firmness in the stored and soaked cherries. The firmness of both bruised and unbruised fruit was affected by at least four factors: a, temperature, b, soaking in water, c, treatment with calcium ions, and d, natural aging or "conditioning" of tissues. The increase in firmness caused by lowering the temperature several degrees was immediate and significant. On the other hand, an increase in firmness due to soaking was evident only after the cherries had been soaked for a relatively long period. Cherries soaked for 24 hours were not significantly firmer than similar cherries stored in air. It is possible, however, that somewhat different results may be obtained with commercially handled cherries. The role of calcium ions in enhancing the firmness of tissues is well known. Changes in firmness associated with physiological aging depended partly on the conditions of storage of the cherries. With prolonged storage at 1° C. (34° F.) there was an increase in firmness of both bruised and unbruised cherries.

Soaking the cherries induced several changes that would not have occurred otherwise. Among these were the leaching of soluble solids and acids from the cherries into the soaking medium, a decrease in percentage of soluble solids, an increase in firmness beyond that attributable to aging or to a lowering of temperature, and, in the case of unbruised cherries, an increase in weight and in the number of cherries which cracked.

The present findings apply only to freshly picked, raw cherries treated under carefully controlled conditions. Similar results were obtained with many different lots of cherries during 1950 and 1951. Application of the findings to commercially handled cherries, however, may be rendered difficult by many variable and un-

TABLE 2

Some effects of bruising red cherries

Cherries and treatment[d]	Firmness before soaking, compression %	Change in weight during soaking %	Loss of soluble solids during soaking[e] %
Experimental cherries			
Control, unbruised	24	+3.8	2.9
Dropped 1 ft.	....	+3.0	4.0
Dropped 2 ft.	25	+2.3	4.6
Dropped 3 ft.	27	+1.7	5.5
Dropped 3 ft. 2 times	32	+0.2	6.4
Dropped 3 ft. 3 times	37	−0.5	8.6
Dropped 3 ft. 4 times	42	−0.6	14.1
Commercial cherries			
1. No treatment	24	....	....
2. No treatment	26	+0.4	....
3. No treatment	26	−0.8	....
4. No treatment	27	+1.5	....
5. No treatment	28	....	....
6. No treatment	29	+1.3	....
7. No treatment	29	+1.1	....
8. No treatment	33	....	....

[d] All samples were soaked in tap water at 10° C. for 23 hours.

[e] Soluble solids leached from the cherries into the soaking medium were determined gravimetrically.

TABLE 3

Effects of bruising and removal of stems on the weight and loss of soluble solids and acids from soaked cherries

Cherries and treatment[f]	Change in weight, %				Loss of soluble solids, %[g]				Loss of acids, %[h]
	Hours soaked				Hours soaked				Hours soaked
	2	7	16	24	2	7	16	24	24
Stems attached	+0.2	+0.8	+1.7	+2.4	0.1	0.1	0.2	0.3	0.6
Stems removed	+1.5	+3.1	+5.4	+7.1	0.7	1.2	2.3	3.1	1.2
Stems removed and cherries bruised	−1.1	−0.7	0.0	+1.0	2.9	4.4	6.5	8.4	10.5

[f] Cherries were soaked in tap water at 10° C. The bruised cherries were dropped twice from a height of 3 feet.

[g] Soluble solids leached from the cherries were determined gravimetrically.

[h] Total acids leached from the cherries were determined by titration and calculated as malic acid.

TABLE 4

Changes in red cherries during storage in air

Temperature [1] and treatment [2] of cherries	Loss in weight, %					Firmness, % compression						Soluble-solids content, %			
	Hours stored					Hours stored						Hours stored			
	2	8	26	51	100	0	2	8	26	51	100	0	26	51	100
21° C.															
Unbruised	1	1	3	5	10	24	23	22	23	24	25	13.9	14.3	14.8	14.9
Bruised	1	2	5	8	13	....	30	31	29	29	29	13.9	14.7	14.6	15.1
10° C.															
Unbruised	0	0	1	1	2	[k]	22	22	23	23	21	13.9	14.5	14.1	14.5
1° C.															
Unbruised	0	0	1	1	1	[k]	21	21	21	20	19	13.9	13.9	14.1	14.3
Bruised	1	1	1	2	2	[k]	27	26	25	23	23	13.9	14.6	14.0	14.2

[1] The relative humidities at 21, 10, and 1° C. were 56, 73, and 81%, respectively.

[2] The bruised cherries were dropped twice from a height of 3 feet.

[k] Initial readings were not made because the cherries had not cooled to the temperatures indicated.

controlled factors which act simultaneously upon the cherries. Among these are extent of bruising, recurrence of bruising, temperature and time interval between bruising and processing, and temperature and time interval between picking and processing.

The yield and quality of heat-processed cherries are not always predictable from the weight and quality of raw fruit *(1, 7)*. Gain in weight associated with soaking unbruised cherries, for instance, does not necessarily mean increased profits to the processor, since much of the gain is lost in the subsequent processing steps. Additional studies will be made on the relation between post-harvest treatments of fresh cherries and the resulting yield and quality of the processed product.

SUMMARY

Unbruised red cherries soaked in water increased in weight and firmness, and decreased in soluble-solids content and acidity. Bruised cherries, however, did not gain significantly in weight and lost appreciable quantities of soluble solids and acids in the soaking medium. The effects of bruising were proportional to degree of bruising. Most commercial cherries are rather severely bruised.

The principal pathway for the exchange of substances between the cherries and the soaking medium was the area of tissue exposed by removal of stems. Both bruised and unbruised cherries became firmer and lost less soluble solids when soaked at 1° C. (34° F.) than when soaked at 10 or 21° C. (50 or 70° F.). Not all the changes that occurred in the cherries during soaking were caused by soaking alone. Cherries stored in air at 1° C. increased steadily in firmness and in percentage of soluble solids. Unbruised cherries kept well under these conditions for as long as 12 days. The firmness of both bruised and unbruised cherries was increased by lowering the temperature, by treating them with calcium ions, by permitting them to age or "condition" naturally, and by soaking them in water.

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